MODULAR HYDROJETTING TOOL

BACKGROUND

[0001] The present invention relates to hydrojetting tools for fracturing oil and gas wells, and more particularly, to a hydrojetting tool with jetting openings which may be sequentially opened during a jetting operation.

[0002] Hydraulic fracturing is often utilized to stimulate the production of hydrocarbons from subterranean formations penetrated by wellbores. In performing hydraulic fracturing treatments, a portion of the formation to be fractured is isolated using conventional packers or the like, and a fracturing fluid is pumped through the wellbore and perforations into the isolated portion of the formation to be stimulated at a rate and pressure such that fractures are formed and extended in the formation. Propping agent is suspended in the fracturing fluid to keep the fractures from closing and thereby provide conductive channels in the formation through which produced fluids can readily flow to the wellbore.

[0003] One method that has been developed for such fracturing is to use a hydrojetting tool having at least one fluid jet forming nozzle. The hydrojetting tool is positioned adjacent to a formation to be fractured, and fluid is then jetted through the nozzle against the formation at a pressure sufficient to form a cavity therein. The high pressure exerted on the formation causes a microfracture to occur. Hydrojetting has been used in cased wellbores as well as uncased ones.

[0004] Hydrojetting has worked well to create a controlled fracture. However, the process is limited in that the method uses a tool that inherently is limited in its ability to deliver large volumes of proppant through the orifices.

[0005] A problem that can arise with hydrojetting is that the jetting nozzles can erode to an extent that they can no longer jet the fluid at a sufficient pressure to cut into the formation. With present hydrojetting tools, the tool must be retrieved from the well and refitted with new jetting nozzles. Obviously, this is a costly and time-consuming procedure. The present invention solves this problem by providing a hydrojetting tool with a series of modules, each module having at least one jetting nozzle therein. The jetting nozzles may be sequentially opened so that a new jetting nozzle is available when it is determined that the previous jetting nozzle has had too much erosion. The tool may be run into the wellbore with as many modules as necessary.

SUMMARY

[0006] The modular hydrojetting tool of the present invention comprises a plurality of jetting modules that can be opened sequentially from the surface when desired. Each module has at least one jetting nozzle therein.

[0007] The invention may be described as a hydrojetting tool for use in a well adjacent to a formation of interest, wherein the tool comprises a plurality of jetting modules, each jetting module having jetting nozzles therein adapted for jetting fluid into the formation The jetting modules may be operated sequentially.

[0008] At least one of the modules has a sleeve therein moveable from a first position covering the jetting nozzles in the one module to a second position covering the jetting nozzles in an adjacent module. A plug may be pumped into engagement with the sleeve for moving it from the first position to the second position. The sleeve preferably comprises an inwardly extending mandrel adapted for engagement by the plug. The plug

may be further pumped through the sleeve after moving it from the first position to the second position thereof.

[0009] Stated in another way, the apparatus is a hydrojetting tool comprising a plurality of jetting modules with jetting nozzles therein adapted for jetting fluid into a well formation, and a sleeve slidably disposed in all but one of the jetting modules. Each sleeve has a first position covering the jetting nozzles in the corresponding jetting module and is moveable to a second position uncovering the jetting nozzles in the corresponding jetting module and covering the jetting nozzles in an adjacent jetting module. The sleeves may be moved sequentially such that the jetting modules may be operated sequentially.

[0010] The apparatus may further comprise a plurality of plugs, wherein each plug may be pumped into engagement with a corresponding one of the sleeves for moving the corresponding sleeve from its first position to its second position.

[0011] In the preferred embodiment, each sleeve comprises an upper sleeve portion which covers the jetting nozzles in the corresponding jetting module when the sleeve is in the first position, a lower sleeve portion which covers the jetting nozzles in the adjacent jetting module when the sleeve is in the second position, and an inwardly extending mandrel disposed between the upper and lower sleeve portions and adapted for engagement by the corresponding plug. The mandrels define holes therein, and the holes are progressively larger from a lowermost sleeve to an uppermost sleeve.

[0012] The jetting module not having a sleeve therein is the lowermost jetting module. The lowermost jetting module may have a shoulder therein for limiting movement of the sleeve in the adjacent jetting module.

[0013] Numerous objects and advantages of the present invention will become apparent to those skilled in the art when the following detailed description of the invention is read in conjunction with the drawings illustrating such embodiment.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] FIG. 1 illustrates a modular hydrojetting tool of the present invention in position in a tool string in a deviated portion of a well.

[0015] FIGS. 2A and 2B show a cross-sectional view of the modular hydrojetting tool.

DESCRIPTION

[0016] Referring now to the drawings, and particularly to FIG. 1, a modular hydrojetting tool of the present invention is shown and generally designated by the numeral 10. Hydrojetting tool 10 is positioned in a wellbore 12 on a tubing string 14. Wellbore 12 is shown as a deviated wellbore that penetrates a subterranean formation 16. Wellbore 12 includes a substantially vertical portion 18 which extends to the surface and a substantially horizontal portion 20 which extends into formation 16. It will be understood by those skilled in the art that hydrojetting tool 10 may be used in virtually any type of wellbore and is not intended to be limited to use in deviated wells.

[0017] Additional tools may be run with hydrojetting tool 10 as desired. For example, but not by way of limitation, a centralizer 22 may be run to keep hydrojetting tool 10 in a central position within wellbore 12. Other tools could also be run with hydrojetting tool 10 but are not shown for simplicity.

[0018] Referring now to FIGS. 2A and 2B, the details of hydrojetting tool 10 will be discussed. Hydrojetting tool 10 comprises a plurality of jetting modules. In the illustrated embodiment, there are a first module 24, a second module 26 and a third module 28. First

module 24 is the lowermost module. Second module 26 is above first module 24, and third module 28 is above second module 26. As will be further described herein, any number of modules can be included in hydrojetting tool 10, and the invention is not intended to be limited to the three shown.

[0019] Hydrojetting tool 10 has a housing 30 which includes an upper adapter 32 connected to tubing string 14 in a known manner. Housing 30 also includes a first module housing 34 which is the outer portion of first module 24, a second module housing 36 which is the outer portion of second module 26, and a third module housing 38 which is the outer portion of third module 28. First module housing 34 is attached to second module housing 36 by a threaded connection 40. Second module housing 36 is attached to third module housing 38 by a threaded connection 42. Third module housing 38 is attached to upper adapter 32 by threaded connection 44.

[0020] First module housing 34 of first module 24 defines a bore 46 therein with an inwardly extending shoulder 48 at the lower end thereof. Above shoulder 48, a plurality of openings 50 are defined in first module housing 34. A first jetting nozzle 52 is disposed in each opening 50. Each of first jetting nozzles 52 defines an orifice 54 therein. First jetting nozzles 52 may be replaceable.

[0021] Hydrojetting tool 10 has a central opening 56 therethrough. In the configuration of hydrojetting tool 10 as it is run into wellbore 12, first jetting nozzles 52 are in communication with central opening 56.

[0022] Second module housing 36 of second module 26 defines a bore 58 therein. A second module sleeve 60 is slidably disposed in bore 58. Second module sleeve 60 has an inwardly extending mandrel 62 therein with a hole 64 therethrough. Extending upwardly

from mandrel 62 is an upper sleeve portion 66, and extending downwardly from mandrel 62 is a lower sleeve portion 68. Second module sleeve 60 is initially held in second module housing 36 by a shear pin 69.

[0023] Above mandrel 62 a plurality of openings 70 are defined in second module housing 36. A second jetting nozzle 72 is disposed in each opening 70. Each of second jetting nozzles 72 defines an orifice 74 therein. Second jetting nozzles 72 may be replaceable. In the configuration of hydrojetting tool 10 as it is run into wellbore 12, second jetting nozzles 72 are covered by upper sleeve portion 66 of second module sleeve 60 so that second jetting nozzles 72 are not in communication with central opening 56. This is a first position of second module sleeve 60.

[0024] Third module 28 is substantially identical to second module 26. Third module housing 38 of third module 28 defines a bore 76 therein. A third module sleeve 78 is slidably disposed in bore 76. Third module sleeve 78 has an inwardly extending mandrel 80 therein with a hole 82 therethrough. Hole 82 in third module sleeve 78 is larger than hole 64 in second module sleeve 60. Extending upwardly from mandrel 80 is an upper sleeve portion 84, and extending downwardly from the mandrel 80 is a lower sleeve portion 86. Third module sleeve 78 is initially held in third module housing 38 by a shear pin 87.

[0025] Above mandrel 80, a plurality of openings 88 are defined in third module housing 38. A third jetting nozzle 90 is disposed in each opening 88. Each of third jetting nozzles 90 defines an orifice 92 therein. Third jetting nozzles 90 may be replaceable. In the configuration of hydrojetting tool 10 as it is run into wellbore 12, third jetting nozzles 90 are covered by upper sleeve portion 84 of third module sleeve 78 so that third jetting

nozzles 90 are not in communication with central opening 56. This is a first position of third module sleeve 78.

[0026] First, second and third jetting nozzles 52, 72 and 90 are illustrated as being oriented substantially perpendicular to a central axis of hydrojetting tool 10 and wellbore 12. However, if so desired, any or all of the first, second and third jetting nozzles 52, 72 and 90 could be positioned at a different angle so that fractures may be initiated at such angles.

OPERATION OF THE INVENTION

[0027] In operation, modular hydrojetting tool 10 is run into wellbore 12 on tubing string 14 in a conventional manner. As already indicated, other tools, such as centralizer 22 may also be run on tubing string 14 as needed. Hydrojetting tool 10 is positioned at the desired location within formation 16.

[0028] As previously discussed herein, hydrojetting tool 10 is initially in a configuration in which first jetting nozzles 52 are open and in communication with central opening 56, and second and third jetting nozzles 72 and 90 are closed and covered by second and third module sleeves 60 and 78, respectively, which are in the first positions thereof.

[0029] Jetting fluid is pumped down tubing string 14 and jetted out first jetting nozzles 52 to begin initiation of fractures 94 in formation 16 and then propagation of propped fractures. As the fracture propagates, fluid rate is increased and injection via the annulus between tubing string 14 and wellbore 12 is initiated and established. Bernouli's principle allows the hydraulic fracture to remain isolated at the point of the jetting, and proppant fluid is pumped in the flow via tubing string 14 and through first jetting nozzles 52. This

proppant increases the erosion process of first jetting nozzles 52, and the pressure due to the nozzle diameter starts to decrease and can be detected at the surface.

[0030] When the operator determines when or if first jetting nozzles 52 have eroded or "washed" out too much for effective further jetting, a plug 96 is dropped into tubing string 14 and pumped down into hydrojetting tool 10. Plug 96 has a plurality of wipers 98 to engage the inner surface of tubing string 14 and has a nose 100 on a lower end. Plug 96 is adapted to pass through hole 82 in third module sleeve 78 and to engage mandrel 62 on second module sleeve 60. Nose 100 is adapted to fit in hole 64 in second module sleeve 60. After plug 96 thus engages second module sleeve 60, further pressure applied will force plug 96 to shear shear pin 69 and move second module sleeve 60 downwardly until it contacts shoulder 48 in first module housing 34. This is a second position of second module sleeve 60. When second module sleeve 60 moves to this second position, it covers and closes first jetting nozzles 52 and uncovers and thus opens second jetting nozzles 72 to communication with central opening 56.

[0031] Further jetting with second jetting nozzles 72 may then be carried out to form additional fractures 102.

[0032] When or if it is determined that second jetting nozzles 72 have incurred too much erosion, then another trip plug 104 is dropped into tubing string 14 and pumped down into hydrojetting tool 10. Plug 104 has a plurality of wipers 106 to engage the inner surface of tubing string 14 and has a nose 108 on a lower end. Plug 104 is adapted to engage mandrel 80 on third module sleeve 78. Nose 108 is adapted to fit in hole 82 in third module sleeve 78. After plug 104 thus engages third module sleeve 78, further pressure applied will force plug 104 to shear shear pin 87 and move third module sleeve

78 downwardly until it contacts the upper end of second module sleeve 60. This is a second position of third module sleeve 78. When third module sleeve 78 moves to this second position, it covers and recloses second jetting nozzles 72 and uncovers and thus opens third jetting nozzles 90 to communication with central opening 56.

[0033] Further jetting with third jetting nozzles 90 may then be carried out to form additional fractures 110.

[0034] While three modules have been shown herein for hydrojetting tool 10, those skilled in the art will see that additional modules could also be used as necessary to carry on jetting of formation 16 until the desired amount of fluid is flowed out formation 16. The above-described procedure would simply be repeated for each module. It is important to note that each succeeding trip plug must be larger than the previous one so that the plug and mandrel systems match and the next series of jetting nozzles are opened and used as desired.

[0035] First module housing 34 has been illustrated herein as having central opening 56 continue below shoulder 48 so that fluid can be flowed through hydrojetting tool 10 to any other tools therebelow and also to allow full circulation of fluid through tubing string 14 and hydrojetting tool 10 as required. Plugs 96 and 104 may be configured so that they can be pumped on through hydrojetting tool 10 by the application of additional pressure thereon to provide for such further fluid flow or circulation. If this flow is not necessary, a lower end of first module housing 34 is simply closed.

[0036] It will be seen, therefore, that the modular hydrojetting tool of the present invention is well adapted to carry out the ends and advantages mentioned as well as those inherent therein. While a presently preferred embodiment has been shown for the

purposes of this disclosure, numerous changes in the arrangement and construction of the parts and steps in the method of use may be made by those skilled in the art. All such changes are encompassed within the scope and spirit of the appended claims.

[0037] What is claimed is: